TELKOMNIKA, Vol.16, No.6, December 2018, pp.2871~2879
ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
DOI: 10.12928/TELKOMNIKA.v16i6.10414

A Small RLSA Antenna Utilizing the Specification of Back Fires 17 dBi LAN Antennas

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Abstract

This research developed a small RLSA antenna that mimics the specification of a Wi-Fi antenna that is available in markets, which is a Back Fires 17 dBi LAN antenna. This research used the size of the back fires antenna as the size for the RLSA antenna. Base on this size, we designed and simulated 71 RLSA antenna models. Among them, we chose a best model and fabricated its prototype. We measured the prototype and found that the measurement result fits the simulation result, thus verifying the correctness of the antenna model. Furthermore, we analysed that with the same size, our RLSA antenna has better performance compared to the back fires antenna, in term of gain (0,53 dB higher), and in term of bandwidth (1075 MHz wider). We also found that our RLSA antenna is lighter and thinner compared to the back fires antenna. We also test the RLSA antenna in real condition for indoor and outdoor communication link. The test showed that the RLSA antenna can performs properly.

Keywords: *antenna for Wi-Fi, small rlsa, back fires antenna, extreme beamsquint*

1. Introduction

Researches in developing small RLSA antennas have been carried out for last decades, such as Tharek [1], Islam [2, 3], Imran [4, 5] in Malaysia, Bialkowski [6-8] in Australia, Hirokawa [9] and Akiyama [10] In Japan. However, the developments of small RLSA antennas were still facing the problem of high reflection coefficients, so that it obstructed the development of small RLSA antennas. In 2012, Purnamirza introduced a technique that able to overcome the problem in small RLSA antenna. The techniques are named the FR4 technique and extreme beamsquint technique. In FR4 technique, RLSA antennas are designed by adding material of FR4 in addition to polypropylene which is normally utilized as material for RLSA cavity. The use of FR4 aims to change wavelength of reflected signal, then the reflected signals are eliminated by other reflected signal from their neighbours slots, thus decrease the reflections [11]. In extreme beamsquint technique, RLSA antennas are designed by using high values of beamsquint angle. The use of high beamsquint values in designing the slot pairs positions will concentrate the slot pairs positions in certain area, so that this will cause most of power from feeder flow to this area and escaped. Since most of power escape from concentrated slot pairs, then the reflection in slot can be reduced [12].

In 2016, Purnamirza has successfully designed a prototype of small RLSA antenna using the extreme beamsquint technique developed in previous research [13, 14]. The prototype was designed to meet the market needs. The result shows that the prototype meets the market needs and performed well in real conditions. Purnamirza continued his research by developing a small RLSA antenna that mimic the specification of patch antennas [15]. This research tried to find out whether RLSA antenna ables to perform as well as patch antenna. This research concludes that with same size, the RLSA antenna can perform better than the patch antenna, especially in term of bandwidth and gain. Referring to this result, this paper investigates the performance of a small RLSA antenna which has same size with other type of antenna that is Back Fires 17 dBi LAN antenna that is also available in markets.

Received June 22, 2018; Revised September 28, 2018; Accepted October 30, 2018

2. Antena Design Steps

The design of the antenna was conducted as follows:

a). Determine the antenna specifications.

We chose one of antenna that commonly available in markets, that is a Back fires 17 dBi LAN antenna as shown in Figure 1. The specification of the Back Fires antenna are the bandwidth of 125 MHz, the gain of 17 dBi, the beamwidth of 250, and the VSWR of 1.5, as shown in Table 1. These specifications were used as the specification of the RLSA antenna that will be achieved.We used the diameter of back fires antenna (listed in Table 1), that is 246 mm, as the diameter of the developed RLSA antenna.

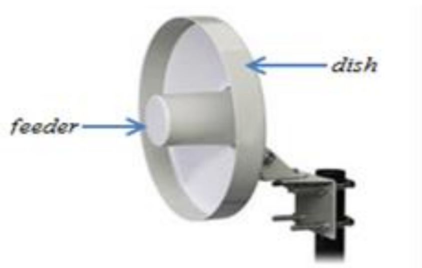

Figure 1. Back fires 17 dBi LAN antennas

Table 1. Back Fires Antenna Specifications

Specifications	Values
Frequency	5725-5850
Bandwidth	125 MHz
Gain	15 dB1
Beamwidth	16^0
Impedance	50 Ohm
S_{11}	-7 dB
Diameter	246 mm
Height	56 mm
Weight	900 gr
Material	Polymer
Feeder connector	Integral N- female

b). Determine the material for the RLSA antenna.

The structure of RLSA antennas consists of 3 main parts. Those are the radiating element, the background element, the cavity, as shown in Figure 2. We chose polypropylene with the permittivity of 2.33 as the cavity material. We also chose copper as the radiating element and the background material. We chose these materials based on the successful of the utilization of these materials in several previous researches [1, 6-8, 11-15]. We referred to Imran [16-18] for the thickness of cavity which is 8 mm.

c). Design the feeder of the RLSA antenna.

In this research, we referred to Imran [16-18] for the feeder design as specified in Table 2. We used a conventional SMA feeder and modified it to fulfil the need of RLSA antenna. We placed a copper disc with the height of 3 mm at the core bar of the SMA feeder, as shown in Figure 3 (a), the definition of feeder specification is shown in Figure 3 (b). The modification of SMA feeder aims to convert the mode signal within the cavity, from TEM coaxial mode within the coaxial cable into TEM cavity mode within the cavity. Hence, signal radiated by feeder will flow radially within the cavity, as shown at Figure 3 (c).

Table 2. Design Parameters of Feeder [16-18]

Specifications Parameters	Symbols	Values
The height of head disc	*h*	3 mm
The diameter of head disc	*ra*	2.8 mm
The lower air gap	*b1*	4 mm
The upper air gap	*b2*	1 mm

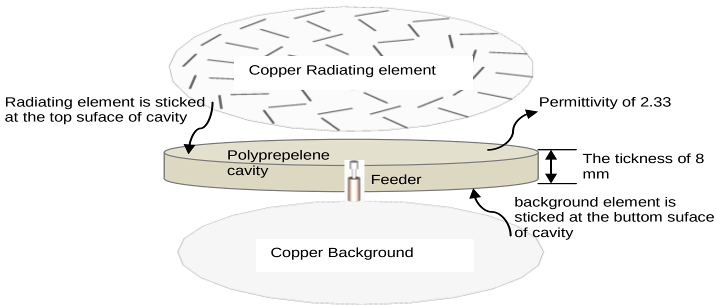

Figure 2. Structures of RLSA antennas [16]

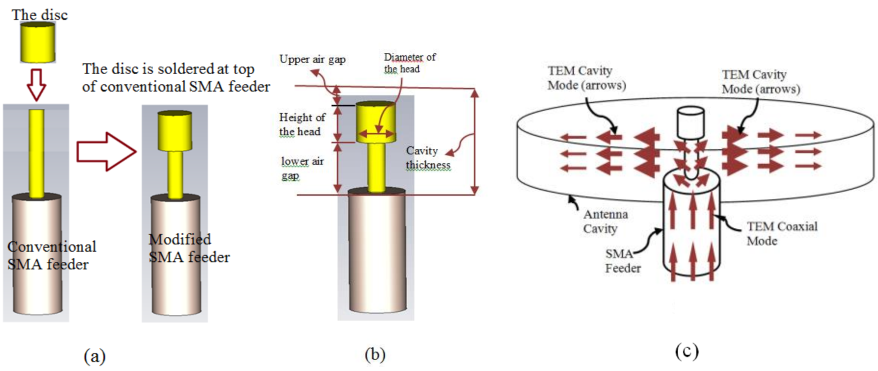

Figure 3. (a) Installation of disc into SMA feeder (b) Definitions of feeder specifications (c) Illustration of the TEM cavity mode and the TEM coaxial mode.[15]

d). Draw RLSA antenna models.

We developed a computer program using Visual Basic Applications (VBA) language in order to calculate the slots positions and orientations. Based on this calculation, the program will automatically draw the slots on the radiating elements of RLSA antennas. This program also draws the RLSA structure along with the feeder. Hence, using this program, we can draw many antenna models within a short time. In this research, we drew 71 antenna models. Each of 71 models has their own unique slot configurations as the result of different design parameters. The parameters are the number of slots in first ring (n varies from 12 to 16) and the beamsquint (Φ varies from 60^0 to 90^0). The other parameters values are listed in Table 3.

Table 3. Parameters of RLSA Antenna [3, 12]

Specifications Parameters	Symbols	Values
Beamsquint angle	Φ	Vary from 60^0 to 90^0
Number of slot pair in first ring	n	Vary from 12 to 16
Wavelength	λ_g	33.88 mm
Slot Length	l	0.5 λ_g
Slot width	w	1 mm
Diameter of antenna	D	246 mm
Cavity thickness	d_1	8 mm
The thickness of radiating element and background	d	0.001 mm
Centre frequency	f	5.8 GHz
The permittivity of cavity	ε_{r1}	2.33

e). Simulate the antenna models.

We simulated the 71 antenna models using simulation software and took their performance parameter, such as gain, radiation pattern, beamwidth, bandwidth, and coefficient reflection. We chose a best model which has the best performance. In this research the best model was the model that was designed using n = 14 and Φ = 70^0. The best model design is shown in Figure 4.

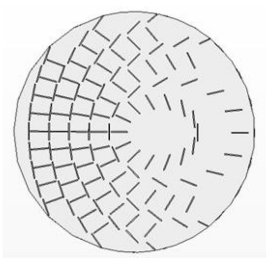

Figure 4. The best simulated model

f). Fabricate the best model

We fabricated a prototype of the best antenna model and the feeder in order to verify the simulation model as shown in Figure 5.

(a) (b)

Figure 5. (a) Fabricated antenna (b) Fabricated feeder

3. Results and Analysis

We simulated the best antenna model and measured its prototype. The measurement was conducted utilizing an Anechoic Chamber to measure radiation patterns and gains, as well as utilizing a Network Analyser to measure reflection coefficients. The measurement activities are shown in Figure 6. The left shows the activity of the measurement in Anechoic Chamber and the right shows the activity of the measurement using Network Analyzer. Figure 7 shows the radiation pattern of the RLSA antenna both for simulation and measurement. From this Figure, we can observe that the simulation fits the measurement result. We get the beamwidth of 26^0 at the main beam of 70^0.

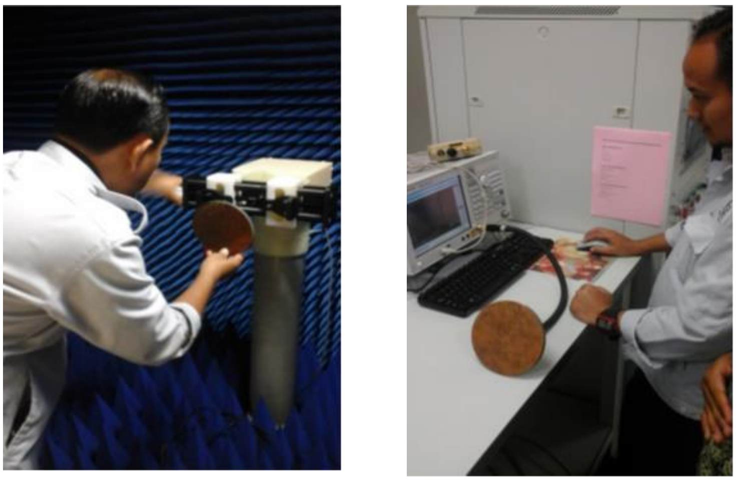

Figure 6. Measurement activities

We compared the peak received power of RLSA antenna with the peak received power of a reference antenna in order to get the gain of the RLSA antenna. The plot of received power of the two antennas is shown in Figure 8. The calculation of gain is as (1)

$$\begin{aligned} G_{RLSA\ Antenna} &= P_{reference\ antenna} - P_{RLSA\ antenna} + G_{reference\ antenna} \\ &= (-15{,}583\ \text{dBm}) - (-17{,}114\ \text{dBm}) + 16\ \text{dBi} \\ &= 17{,}531\ \text{dBi} \end{aligned} \quad (1)$$

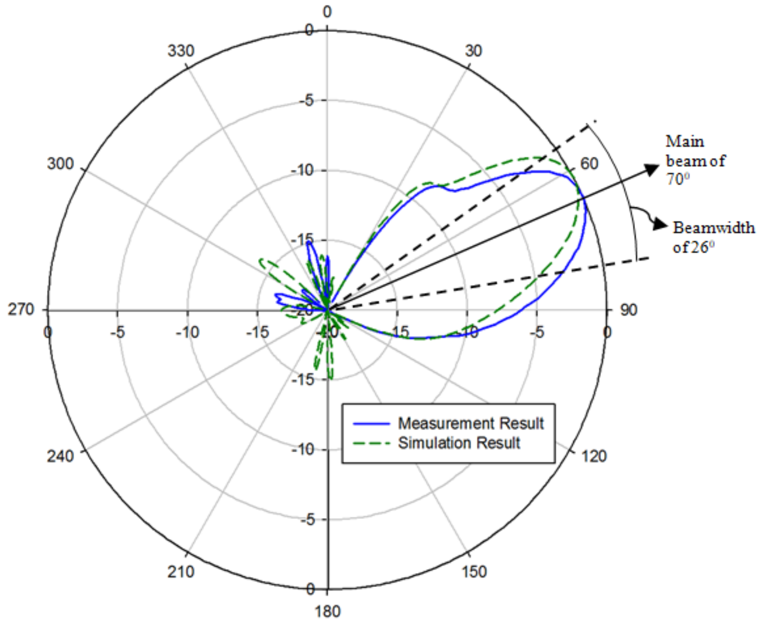

Figure 7. Radiation pattern

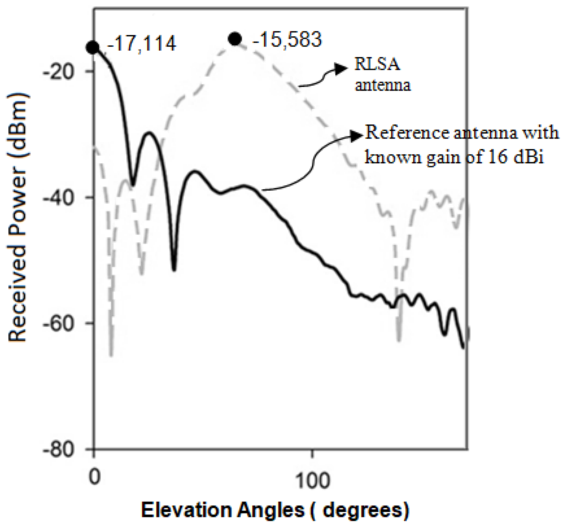

Figure 8. Plot of received power of RLSA and reference antenna

Figure 9 shows the respond of reflection coefficient both for measurement and simulation results. This Figure shows that the RLSA antenna has the wide bandwidth of about 1.2 GHz. In Figure 7 and Figure 9, we can observe that the measurement results are quite agreed with the simulation results. The slight differences between them are due to some imperfections in fabricating the antenna and the feeder. As mentioned earlier in section 2, the antenna materials are not compact material, but they are separated materials which are combined by sticking them together as shown in Figure 2. Hence, When they were combined, there was a slightly shift from the correct position. The slightly shift also occurred when soldering the head disc into the feeder as shown by Figure 3 (a). The imperfection is also caused by the slight change of cavity permittivity value due to the utilization of glue to stick the radiating element and the cavity.

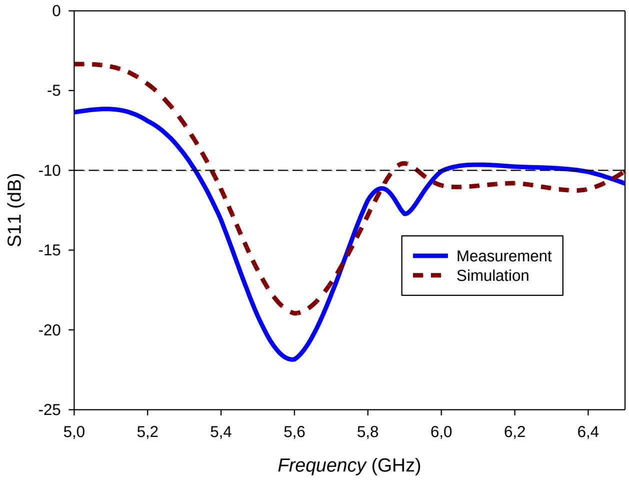

Figure 9. The response of reflection coefficient (dB)

We measured the polarization of the RLSA antenna by rotating the antenna in azimuth direction while capturing the received power. The direction of antenna rotation and the direction of antenna polarization are shown by Figure 10 (a). The received power as function of rotation angle is polar plot in and shown in Figure 10 (b). From Figure 10 (b), It can observed that the RLSA antenna has a pure linear polarization as match with the theory. All the measurement values of RLSA antenna are compared to the back fires antenna as listed in Table 4.

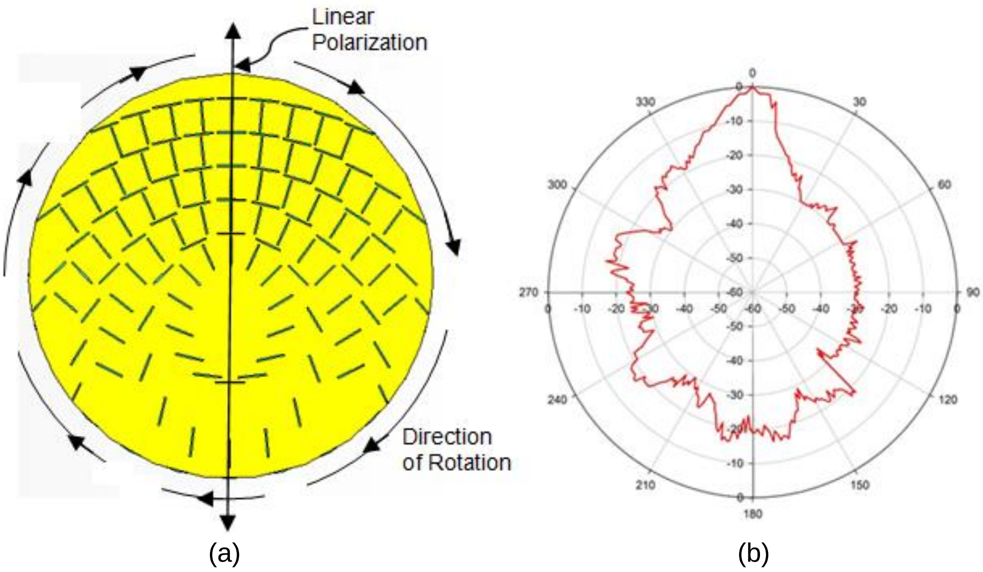

Figure 10 (a). Direction of antenna rotation (b) Plot of received signal

Table 4. Comparison between RLSA and Back Fires

Specifications Parameters	RLSA antenna	Back Fires Antenna
Gain	*17.53 dBi*	17 dBi
Bandwidth	1200 MHz	125 MHz
Beamwidth	26^0	25^0
VWSR	1,68	1,5
Diameter	246 mm	246 mm
Thickness	8,2 mm	56 mm
Weight	300 gr	900 gr

From Table 4, we can observe that the RLSA antenna has higher gain of 0.53 dB than the Back Fires antenna. The RLSA antenna also has much wider bandwidth (1200 MHz) compared to the Backfires Antenna (125 MHz). From Table 3, we also analysis that in term of dimension, with same diameter, RLSA antenna is much thinner and lighter than the Back fires antenna. In order to test the performance of RLSA antenna in real condition, we built a testbed system. The testbed consists of two transceiver as shown in Figure 11. At transceiver A, The RLSA antenna is connected to an Access Point using a Pigtail cable RG-147 SMA male to RP-SMA male. The access point is connected to a computer using UTP cable. At transceiver B, a 5.8 GHz wireless access point is connected to a computer using a UTP cable. We conducted a communication between transceiver A and transceiver B for indoor and outdoor. The test showed that the communication could establish as usual, thus verify the good performance of RLSA antenna.

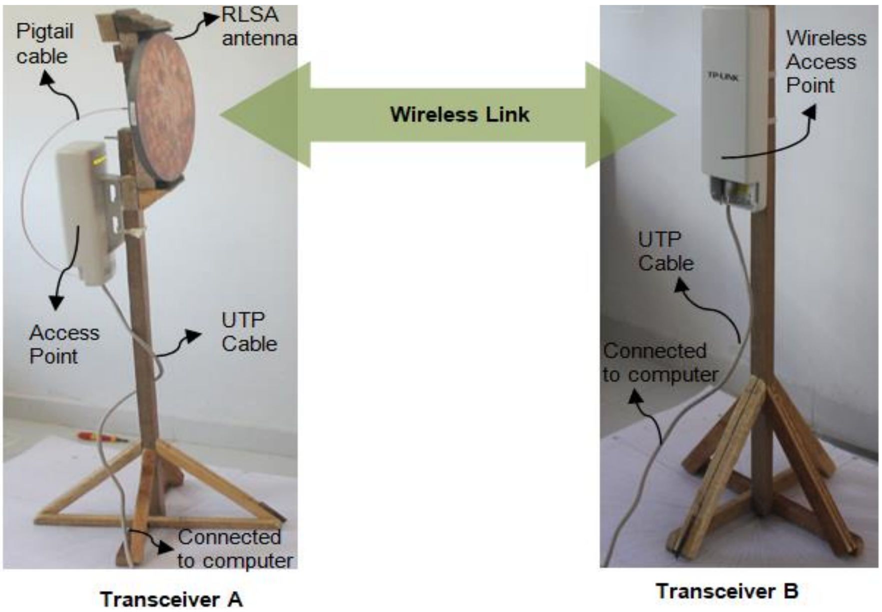

Figure 11. Testbed system

4. Conclusion

We have developed a RLSA antenna with the size and the specification of a back fires antenna that usually found in market. We designed and simulated 71 antenna models and chose a best model. The best model then fabricated and measured. We conclude that the performance of RLSA antenna is better in term of gain and bandwidth. We also found that the RLSA antenna is much thinner and lighter compared to the back fires antenna. We also test the RLSA antenna in real condition and found that the RLSA antenna can perform its function well.

Acknowledgments

We would like to thank Lembaga Penelitian dan Pengabdian Masyarakat (LPPM) UIN Suska for partially funding this research. Thank also goes to Computer Simulation Technology Malaysia Sdn. Bhd, for giving a temporary licence to use CST STUDIO SUITE™ Software as simulation software in our research. Appreciation also goes to Advance Microwave Laboratory, Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Malaka for the technical assistances in conducting antenna measurement.

References

[1] Tharek AR, Ayu IKF. *Theoretical investigations of linearly polarized radial line slot array (RLSA) antenna for wireless LAN indoor application at 5.5 GHz*. Proceedings of the Mediterranean Electrotechnical Conference- ELECON. 2002: 364-367.

[2] Islam MRU, Tharek AR. *Novel and simple design of multi layer Radial Line Slot Array (RLSA) antenna using FR-4 Substrate*. Proceedings of Asia-Pacific Symposium on Electromagnetic Compatibility and 19th International Zurich Symposium on Electromagnetic Compatibilit (APEMC). 2008: 843-846.
[3] Islam MRU. *Simple integrated system for wireless backhaul networks*. Proceedings of the International Conference on Computer and Communication Engineering 2008 (ICCCE08). 2008: 341-345.
[4] Ibrahim IM, Purnamirza T, Tharek AR, Sabran MI. *Radial Line Slot Array antenna development in Malaysia*. Proceeding of 7th European Conference on Antennas and Propagation (EuCAP). 2013: 174–178.
[5] Ibrahim IM, Tharek AR, Sabran MI. *Wide band open ended air gap RLSA antenna at 5.8GHz frequency band*. Proceeding of IEEE International Conference on Wireless Information Technology and Systems (ICWITS). 2012:1-4.
[6] Bialkowski KS, Zagriatski S. *Investigations into a dual band 2.4/5.2GHz antenna for WLAN applications*. Proceeding of 15th International Conference on Microwaves, Radar and Wireless Communications (MIKON–2004). 2004: 660-663.
[7] Bialkowski KS, Zagriatski S. *A dual band 2.4/5.2GHz antenna including a radial line slot array and a patch*. Proceeding of IEEE Antennas and Propagation Society AP-S International Symposium (Digest). 2004: 3095-3098.
[8] Zagriatski S, Bialkowski ME. *Circularly polarised radial line slot array antenna for wireless lan access poin*t. Proceeding of 15th International Conference on Microwaves, Radar and Wireless Communications (MIKON–2004). 2004: 649-652.
[9] Hirokawa, J. *Matching slot pair for a circularly-polarised slotted waveguide array*. Proceeding of IEE Microwaves, Antennas and Propagation. 1990; 137: 367-371.
[10] Akiyama A. *Design of radial line slot antennas for millimeter wave wireless LAN*. Proceeding of IEEE Antennas and Propagation Society AP-S International Symposium (Digest). 1997: 2516-2519.
[11] Purnamirza T, Tharek AR. Jamaluddin MH. The Extreme Beamsquint Technique to Minimize the Reflection Coefficient of Very Small Aperture-Radial Line Slot Array Antenna. *Journal on Electromagnetic Wave and Application*. 2012; 26: 2267-2276.
[12] Purnamirza T, Tharek AR. A Novel Technique in Simplifying the Fabrication Process and in Improving the Reflection Coefficient of the Linear Polarized Radial Line Slot Array (LP-RLSA) Antennas. *Journal on Electromagnetic Wave and Application*. 2012; 26: 535-548.
[13] Purnamirza T, Kristanto D, Ibrahim IM. A Design of Compact Radial Line Slot Array (RLSA) Antennas for Wi-Fi Market Needs. *Progress In Electromagnetics Research Letter*. 2016; 64: 21-28.
[14] Purnamirza T, Ibrahim IM, Prowadi P, Amillia F. Small Radial Line Slot Array (RLSA) Antennas for Wi-Fi 5.8 GHz Devices. *International Journal on Communications, Antenna and Propagation (IRECAP)*. 2017: 397-402.
[15] Purnamirza T, Hasbi S, Ibrahim IM, Mulyono, Amillia F, Rahmi D. A Radial Line Slot Array (RLSA) Antenna with the Specifications of 16 dBi Outdoor patch Antenna. *TELKOMNIKA Telecommunication Computing Electronics and Control*. 2018; 16: 46-52.
[16] Imran IM, Tharek AR. *Radial line slot antenna development for outdoor point to point application at 5.8GHz band*. Proceeding of 2004 RF and Microwave Conference. 2004: 103-105.
[17] Imran IM. *An optimization of beam squinted radial line slot array antenna design at 5.8 GHz*. Proceeding of 2008 IEEE International RF and Microwave Conference. 2008: 139-142.
[18] Imran IM. *Beam squinted Radial Line Slot Array Antenna (RLSA) design for point-to-point WLAN application*. Proceeding of 2007 Asia-Pacific Conference on Applied Electromagnetics. 2007: 1-4.